Northwest Fisheries Science Center

Highlights 2009

January 2010

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Message from the Science Director

As we welcome a new year, I would like to share with you some of the activities and accomplishments of NOAA's Northwest Fisheries Science Center in 2009. I am proud of what Center staff achieved and appreciate the contributions of our collaborators, both within and outside the NOAA family. Among our accomplishments this past year, the Center led a new effort to respond to emerging environmental concerns such as ocean acidification and climate change, and rose to the challenge to provide critical scientific advice to our West Coast stakeholders for salmon recovery and cultivate partnerships with regional governance efforts such as the Puget Sound Partnership and the West Coast Governors' Agreement on Ocean Health. The Center also continued advancing its strategic science and research planning efforts to ensure that our activities remain of the highest quality, meet current and long-range societal needs, and are completed in an efficient and cost-effective manner. While we continue to face critical challenges in protecting and conserving Pacific Northwest ecosystems, we have made many important strides and I look forward to continuing our efforts in 2010.

Sincerely,

Usha Varanasi

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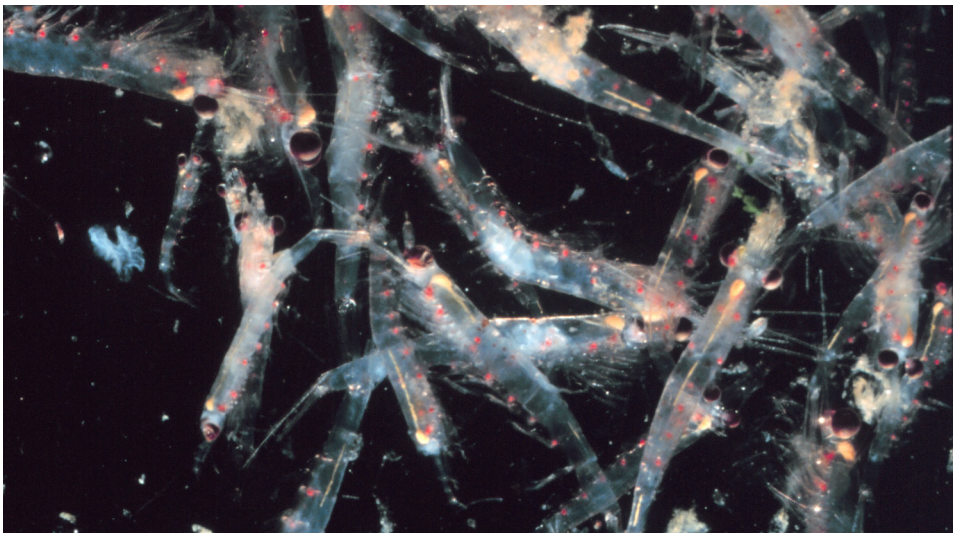
Who We Are and What We Do

The Northwest Fisheries Science Center (NWFSC or Center) conducts research to help conserve and manage living marine resources (e.g., marine fish, salmon, and killer whales) and their habitats in the Northeast Pacific Ocean—primarily off the coasts of Washington and Oregon and in rivers and streams in Washington, Oregon, and Idaho where anadromous fish, like salmon, exist. Our research assists resource managers in making sound decisions that build sustainable fisheries, recover endangered and threatened species, sustain healthy ecosystems, and reduce risks to human health. The Center conducts research in four primary areas:

- Ecosystem Approach to Management for the California Current Large Marine Ecosystem
- Habitats to Support Sustainable Fisheries and Recovered Populations
- Recovery, Rebuilding and Sustainability of Marine and Anadromous Species
- Oceans and Human Health

What follows are some of the Center's 2009 accomplishments in each of these areas.



Ecosystem Approach to Management for the California Current Large Marine Ecosystem

The Pacific Northwest's waters are part of the California Current Large Marine Ecosystem (CCLME), which stretches from British Columbia to Baja California and is one of the most productive coastal ecosystems in the world. The CCLME is home to an abundance of marine life, sustains many active fisheries, modulates weather patterns, and plays a vital role in the region's economy. Center scientists work to support an ecosystem approach to management of the CCLME, which requires an understanding of the processes, functions, and interactions among organisms, including humans, and their environment. This approach is especially timely with recent development of new initiatives such as NOAA's Next Generation Strategic Plan and the Ocean Policy Task Force's draft guidance on Coastal and Marine Spatial Planning.

In 2009 we:

Developed Novel Approach to Investigate Ocean Acidification

Ocean acidification is caused by anthropogenic increases in atmospheric carbon dioxide that is then absorbed by the oceans, increasing its acidity and decreasing the levels of carbonate that is crucial to species that use calcium carbonate to form their shells. The West Coast and North Pacific are susceptible to ocean acidification, and the level of corrosive ocean waters is accelerating faster than models have predicted. This increasing acidity can disrupt the calcification process of shell-producing organisms at the base of the food chain, such as krill, and can lead to a ripple of negative effects on other species of commercial and conservation concern. In 2009, scientists designed a state-of-the-art acidification experimental facility that provides seawater with controlled pH, carbon dioxide, and dissolved oxygen levels for multiple, simultaneous experiments on diverse marine organisms. The facility will allow researchers to study the susceptibility of key species to an acidified ocean environment under realistic scenarios of future levels of carbon dioxide in the atmosphere, assess the ecosystem impacts on food web dynamics, and determine where ocean acidification has already had impacts on marine species.

Continued Development of an Integrated Ecosystem Assessment

An Integrated Ecosystem Assessment (IEA) is an invaluable management tool because it synthesizes and analyzes all available information related to organisms, processes and habitat; identifies ecosystem indicators and risks; and evaluates the efficacy of different management approaches. This past year, a team of Center scientists, in collaboration with the Puget Sound Partnership (PSP), developed quantitative approaches to carry out an IEA in support of a large-scale ecosystem effort in Puget Sound. A total of six human and natural system goals were identified along with a list of recommended indicators, and newly developed marine food web models helped identify additional indicators that are not currently being monitored in the Puget Sound ecosystem. Additionally, scientists began to develop and use quantitative models to evaluate alternative management strategies and the economic consequences of food-web based changes, revealing initial estimates that a doubling in important near-shore habitat (such as eelgrass) through protection or restoration would increase the value of commercial fisheries alone by almost $1 million. These efforts in Puget Sound will provide a solid basis for recovery and management efforts in the region and serve as the model for future work to develop an IEA for the California Current in collaboration with the West Coast Governors' Agreement on Ocean Health (WCGA).

Krill are a critical species in the marine food web and vulnerable to the effects of ocean acidification. (above)

Used Ocean Indicators to Detect Changes in State of Northern California Current Large Marine Ecosystem

Over the past decade, the Center has been monitoring the ocean environment off the Washington and Oregon coasts, its interaction with the California Current, and how ocean conditions affect the abundance, growth, distribution and survival of salmon. Using a recently developed ocean index tool that combines oceanographic data with biological indicators, scientists were able to capture the dynamics of a changing ecosystem in 2008-2009 and predict resulting salmon returns for Chinook and coho salmon. In 2008, scientists tracked one of the highest levels of ocean productivity observed on record, with a negative Pacific Decadal Oscillation (PDO) index that hadn't been observed in over 50 years, the coldest sea surface temperatures in Pacific Northwest waters in over 35 years, and the highest copepod biomass measured in 6 years; these indicators lead scientists to predict good adult salmon returns, a number confirmed by precocious jack returns this year. In 2009, scientists noted that ocean conditions took a turn for the worst, with a positive PDO index, warmer sea surface temperatures, reduced copepod biomass, and a massive infusion of a sub-tropical predator, the Humboldt squid. The ability of the suite of indicators to capture the transition of the CCLME ecosystem from a productive to a less productive ecosystem will allow managers to more quickly adjust harvest rates of important living marine resources and ensure their sustainability for future use.

Scientists track individual SRKWs to identify prey and areas where they feed throughout their summer range. (above)

Habitats to Support Sustainable Fisheries and Recovered Populations

Living marine resources in the Pacific Northwest use and depend on a variety of habitats from freshwater streams and rivers to estuaries and the ocean. Center scientists conduct research to better understand these habitats and how they impact species and ecosystem structure and function.

In 2009 we:

Identified Killer Whale Prey in Summer Habitat Range

The Center took a lead role in conducting studies to provide information to managers of fisheries and other federal projects to improve their ability to assess how the projects or activities could potentially affect the habitat of endangered Southern Resident killer whales (SRKW) and Chinook salmon. Scientists recently completed a five-year study of SRKW prey consumption in their summer range, and their results confirmed that killer whales preferentially select Chinook salmon, that the stocks they consume are primarily from the Fraser River, and that the stocks of importance vary seasonally. Another groundbreaking study modeled the energetic needs of every individual in the SRKW population. The results of these two studies were fundamental to analyses of the potential impacts of fisheries to the SRKW population.

Showed How Pesticide Levels May Hinder Recovery of Wild Salmon Populations

Center scientists determined that short-term, seasonal exposure to sub-lethal levels of pesticides such as diazinon and malathion in rivers and basins may limit the growth and size of wild salmon populations, and thus inhibit the recovery of threatened or endangered populations. A model, reflecting realistic pesticide use across various landscapes and over time, showed that a pesticide exposure lasting only four days can 1) change the freshwater growth and, by extension, the subsequent survival of sub-yearling salmon and 2) that the seasonal transport of pesticides to salmon habitats over successive years might slow the recovery of depressed populations. These results show the importance of evaluating chemical habitat quality, as well as other physical and biological stressors, when prioritizing habitat restoration strategies for salmon recovery.

Recovery, Rebuilding and Sustainability of Marine and Anadromous Species

Over the last several decades certain living marine resources have become depleted and, in some cases, are in danger of extinction. In the Pacific Northwest, approximately 39 marine species are listed as endangered or threatened under the Endangered Species Act and seven marine fish stocks are classified as "overfished" under the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act. Recovering and rebuilding these populations and sustaining all marine and anadromous populations are important for ecological, economic, social, and cultural reasons.

In 2009 we:

Conducted Killer Whale Studies to Help Managers Develop Vessel Noise Regulations

Southern Resident killer whales are listed as endangered under the Endangered Species Act and are unique among killer whales in that they rely on a major urbanized estuary, Puget Sound, Washington, as critical habitat. Given their dependence on sound for communication and the many anthropogenic sources of noise in Puget Sound, it is critical to understand acoustic impacts on SRKWs. Researchers found that vessels regularly approached Southern Residents within the current guideline of 100 meters and that approaches by vessels of up to 150 to 200 meters can elicit surface active behaviors in SRKWs, which could cause this endangered species to expend more energy during hunts for food, even as their preferred prey (Chinook salmon) are on the decline. Researchers also found that SRKWs call louder as ambient noise levels increase. When many vessels are present, vessel noise could completely mask their calls or significantly decrease the range over which whales can communicate with one another, which may limit the extent to which they are able to disperse to find food. These studies added to existing data that already prompted NOAA Fisheries to propose new rules to keep orcas even further away from vessel traffic in Puget Sound.

Improved Model to Predict Salmon Survival in the Columbia River Hydropower System

The Columbia and Snake Rivers are used and valued for ecological, economic, social, and cultural reasons. These rivers are home to endangered and threatened Pacific salmon, provide irrigation for millions of acres of farmland, transport goods, support commercial and tribal fisheries, and generate electric power via a series of dams. Due to these multiple and varied uses, Center scientists and collaborators throughout the Pacific Northwest developed a model to describe juvenile salmon passage through the Columbia and Snake rivers. In 2009, scientists added new components to the Comprehensive Passage (COMPASS) model which will help predict how future dam and reservoir operations in the upper Columbia River will affect juvenile salmon survival and provide estimates of latent mortality (downstream of the hydropower system). Outputs from the COMPASS model provided the scientific foundation necessary for NOAA Fisheries to develop strategies for river operations to increase survival of juvenile fish on the Columbia River. Future efforts will focus on evaluating the potential benefits of juvenile salmon transportation (from dams to release sites downstream) on adult return rates and on understanding the potential influence of ocean conditions on stock returns.

Expanded Genetic Database and Population Data for Coho Salmon

The Center led a collaborative, coast-wide effort to standardize genetic data for coho salmon and upload a geographically broad set of population data to the GAPS (Genetic Analysis of Pacific Salmon) database. Working with five salmon genetics laboratories, scientists converted existing genotypes to a standard format for nearly 9,000 fish from 110 locations along the West Coast and Alaska. Initial analyses of the coast-wide dataset allowed scientists to estimate the genetic relationships and determine stock composition of a mixture of coho salmon within a high (95%) confidence interval. The capability to produce high-quality, centralized genetic data for salmon has helped the Center develop more collaborative projects with federal, state and tribal organizations and make valuable contributions toward ecosystem-level research.

Collected Critical Data on West Coast Groundfish

The West Coast groundfish fishery includes some 90 commercially fished stocks and supports millions of dollars in economic activity. Center scientists conducted three coast-wide groundfish surveys using state-of-the-art sampling technology and techniques: a bottom trawl survey from Cape Flattery, Washington to the U.S.-Mexican border; a hook and line survey in rock habitat; and a Pacific hake acoustic survey (conducted jointly with Canada) from central California to the Alaska-Canadian boundary. These surveys are a key source of fishery-independent information about the distribution,

abundance, and age structure of groundfish that is needed to support stock assessments of managed species. This year the Pacific Fishery Management Council approved the Center's 10 stock assessments for West Coast groundfish species as well as rebuilding analyses for 5 overfished stocks, and is using these specifications to set harvest levels.

Assisted in Recovery of Redfish Lake Sockeye Salmon

Redfish Lake sockeye salmon travel over 900 miles from the Pacific Ocean up the Columbia and Snake Rivers to their natal stream and spawning grounds in Idaho's Redfish Lake Creek. With 8 large dams along the river, however, these salmon have a difficult journey and their populations have dwindled. With less than six fish returning, in 1991, Redfish Lake sockeye salmon were listed as endangered under the Endangered Species Act. As part of a multi-agency captive broodstock program to protect the genetic structure and prevent the further decline of Redfish Lake sockeye salmon, Center scientists in collaboration with others developed techniques to successfully culture sockeye salmon to adulthood and rear and release juveniles. As a result of these efforts, in 2009, a record 833 adult sockeye salmon returned to Redfish Lake--a level that has not been seen in over 40 years. This increase in returns should help stabilize the population until factors leading to their decline, such as loss of downstream rearing habitats, can be more fully addressed. The innovative captive broodstock program exemplifies the science-based tools NOAA is using in its comprehensive efforts to recover ESA-listed stocks of Pacific salmon.

Advanced Fish Tagging and Detection Technology

The passive integrated transponder tag (PIT tag) is a small device, about the size of a grain of rice, with a computer chip that is inserted into the body cavity of juvenile salmon. Electronic systems at dams detect PIT tags in juvenile salmon as they move downstream and send information to a centralized database so that scientists can learn more about fish passage and survival. This year, Center scientists conducted research to develop additional PIT-tag capabilities, including building and testing a prototype for a mobile PIT-tag research vessel as well as designing a complex new tagging system for dam spillways that will greatly reduce the standard errors of current salmon survival estimates. Scientists also developed a series of new PIT-tag detection systems for the Willamette River as part of a multi-agency effort to inform fish passage design decisions. Improvements to these detection systems will help provide critical information regarding salmon migration, behavior, passage and survival of ESA-listed stocks.

Achieved First Hatchery Production of Sablefish in U.S.

Hatcheries are fish breeding and raising centers that have been built primarily to enhance harvest and reduce the impacts of development that destroy or degrade salmon habitat and block migratory routes. This year, the Center continued investigating methods to improve the survival of juvenile sablefish in captivity. By applying their advanced understanding of each stage in the sablefish's life history, a team of scientists successfully produced 26 juveniles from approximately 30 million eggs provided by 27 females. This success rate, while low, is on par with what nature provides. Scientists will continue improving this procedure to increase the survival of this important species, which will help meet the agency's goal of developing technologies to support sustainable marine aquaculture.

Addressed Need for Sustainable Feeds for Marine Organisms

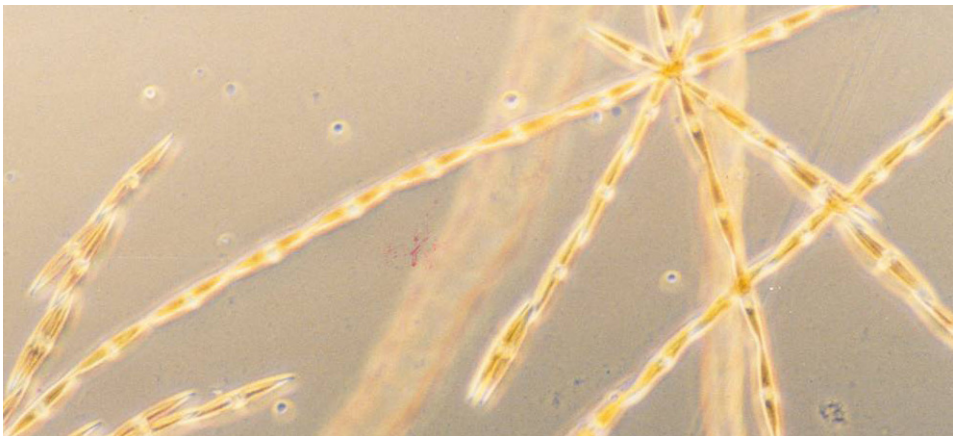
Fish-meals and oils provide the majority of essential nutrients needed by farmed (cultured) marine fish as well as human health benefits for seafood consumers. Given the limited supply of these resources and the growing demand for economic and efficient feeds for seafood production, the Center and collaborators are working to identify more sustainable aquaculture feeds. This year, scientists began formulating a new diet for sablefish devoid of fishmeal and oil, a cost-effective technology to extract oil and protein from fishery processing wastes, and a process to transfer heart-healthy omega-3 fatty acids from feed to coho salmon tissue and eggs. Scientists also developed a specialized technology to develop high-quality larval feeds, an efficient process which could potentially result in healthier fish, improve fish survival at various life stages, and minimize environmental impacts.

FSV Pisces and *Bell M.Shimada* at sea. (opposite page)

Scientist measures length of juvenile rockfish. (above left)

Sockeye salmon returned to Redfish Lake in record numbers this year. (credit Idaho Fish and Game) (above middle)

Scientists taking eggs from a female sablefish. (above right)



Oceans and Human Health

We are inextricably linked to the oceans: our activities on land, sea, and in the air impact the health of the oceans and the health of the oceans impacts us. As NOAA's West Coast Center of Excellence for Oceans and Human Health, Center scientists focus on advances in early warning systems, seafood benefits and risks, and improved assessments of ecosystem change and its effects on human health through studies of pathogens, toxin-producing algae, shellfish, fish and marine mammals, as well as important environmental factors, including climate variability and change.

In 2009 we:

Estimated Economic Impacts of Harmful Algal Blooms on Razor Clam Harvesting and Washington State's Coastal Economy

Harmful algal blooms (HABs) occur when a particular species of toxic algae proliferates. Through feeding, these toxins can be transferred through the food web. One of the toxins heavily impacting the Pacific Northwest is domoic acid, which is produced by the algae *Pseudo-nitzchia*. Beach and shellfish closures resulting from these blooms have had severe social and economic impacts on both coastal and tribal communities. Scientists and their collaborators found that a year-long closure in recreational razor clam digging because of toxic algae could cost Washington state as much as $22 million in lost sales to coastal counties. Reduced lodging, transportation, and dining sales would also translate to a direct loss in labor income of $13.3 million to residents of affected areas, including a small commercial fishery. The study also factors in a significant income loss for the Quinault tribe, for whom the razor clam fishery is very important to its economic well-being. This groundbreaking report is one of few that collected and analyzed data to reveal the economic impacts of HABs on a major recreational fishery, and is part of a larger NOAA-funded effort to monitor and forecast blooms and prevent unnecessary or excessive harvest closures, reduce public health risks, and minimize economic impacts.

Helped Accelerate Vaccine Development for Salmon Bacterial Kidney Disease

Bacterial Kidney Disease (BKD) is a chronic, debilitating disease with high mortality that impacts salmon raised in hatcheries, fish farms, and programs designed to help maintain endangered and threatened salmon stocks. While scientists and managers have long been aware of the threats that BKD poses, there are currently no completely effective vaccines or antibiotic treatments to treat infections by *Renibacterium salmoninarum*, the bacterium that causes BKD. Having already sequenced the entire genome of *R. salmoninarum*, Center scientists turned their attention this year to testing molecular endpoints that can be used to screen potential vaccines against BKD. Scientists discovered that Chinook salmon "hosts" expressed a different suite of genes in an effective response to the infectious bacterium. Unlike traditional endpoints that may take longer to assess or have undesirable effects (such as mortality), the use of molecular endpoints can accelerate vaccine testing and development to prevent endemic bacterial diseases and protect fish health.

Advanced Understanding of an Important Bacterial Pathogen

Vibrio parahaemolyticus is responsible for nearly half of *Vibrio*-related infections in the United States and is contracted through the ingestion of raw shellfish, like oysters. Since 1995, the majority of *V. parahaemolyticus* infections worldwide have been caused by strains that belong to a single "pandemic" group of the bacterium. However, recent evidence has shown that strains causing infections in the Pacific Northwest do not belong to the pandemic group. Using phenotypic, genetic, and genomic comparison methods, Center scientists have confirmed that the majority of clinical strains from Puget Sound are members of a distinct clonal group, genetically distinct from strains that belong to the pandemic group. Interestingly, the majority of environmental strains in Puget Sound are genetically similar to the pandemic group, yet are not causing infections in the Pacific Northwest. These advances are crucial to the identification of genetic markers that differentiate the pathogenic strains from the Pacific Northwest for the development of improved risk assessment and early warning forecasting tools. With this information and continued research, we hope to eventually develop methods to forecast the presence of pathogenic *V. parahaemolyticus* in shellfish before they are eaten, eliminating this serious cause of seafood-related illnesses.

Our Facilities, Operations & Staff

Scientists and staff are the heart of the Center and are its most important asset. Adequate facilities and a strong infrastructure are critical to supporting the high-quality work we strive to achieve.

In 2009, we:

Supported Key Regional Collaboration Efforts

Center scientists continued their valuable support in regional activities to improve coastal and ocean health, as part of ocean governance (i.e., PSP, WCGA) and NOAA's regional collaboration initiatives. In the past year, several Center staff served on key committees and panels for the WCGA and PSP, providing critical science advice and guidance for key state partners. Center scientists were actively engaged in science activities to support the Action Agenda of the PSP and the WCGA Executive Committee and Action Coordination Teams. These efforts showcased the value of NOAA science and expertise to our regional constituents. For NOAA's Western Region Collaboration Team (NOAA West), the regional team leader, a Center senior manager, along with the newly appointed Team coordinator and members from other NOAA line offices conduct activities of importance for the U.S. Western region. NOAA West supported NOAA's Next Generation Strategic Planning initiative by conducting a series of forums with key stakeholders, including the WCGA and the Integrated Ocean Observing System (IOOS), to get valuable input on priorities NOAA should consider in the future.

Advanced Center Research Planning

In 2009, the Center put a research planning and implementation infrastructure in place as a result of the Center's Strategic Science and Research Plan adopted in 2007. The infrastructure consists of: 1) Executive Council, responsible for overall decision-making, 2) Executive Panel, responsible for plan deployment, and 3) Research Council, responsible for plan development and research prioritization. In addition, near-term priorities (NTPs), which address critical research needed in the next year or two, were selected. The NTPs include an integrated ecosystem assessment for Puget Sound; identification of biological and economic tradeoffs in freshwater use under climate change; surveys in untrawlable, unsurveyed or protected areas; expansion of our knowledge of the ocean ecology of adult salmon; development of a web accessible system for algal toxin detection protocols for West Coast marine mammal and fish species; and initiation of an ecosystem-based aquaculture program with sablefish in Puget Sound. In addition, the Center is actively involved in NOAA's Next Generation Strategic Plan (NGSP) with senior staff currently serving on the NGSP Steering Committee and Working Group.

Worked to Improve Environmental Literacy and Stewardship

Center staff participated in local education and outreach events, including the NOAA Science Camp, NWFSC's Kids Day, the Seattle Aquarium's Family Science Weekend, and the SMART Girls annual science workshop that helps middle school girls pursue interests in science, technology and math. The Center also partnered with the Seattle Aquarium for a 9-month photographic exhibit attended by over 150,000 visitors, featuring marine life images taken with the NWFSC's scanning electron microscope. Center staff also co-led the development of two regional marine educator workshops (for 60 educators total) and a unique educational SRKW workshop covering the latest science and management issues about this endangered species for over 175 naturalists and boat operators in the U.S. and Canada. In addition, to help increase interest in careers that support NOAA's mission, the Center provided over 50 students with internship opportunities at the Center. In providing these internship opportunities, the Center continued to support the participation of students with disabilities through the Washington State DO-IT program.

Pseudo-nitzschia, the organism that produces domoic acid. (opposite page, left)

Vibrio parahaemolyticus can be found in oysters. (opposite page, right)

K-12 Teachers practice sampling fish as part of the marine education workshop. (above left)

Visitors learn about watersheds and pollution at Seafest. (above right)

Highlights 2009

Improved Safety and Operations

Center staff conducted a number of risk assessments to help minimize accidents and injuries in the workplace and provided a variety of training opportunities to staff, including CPR/first aid and ergonomics safety. The Center also developed an Environmental Management System (EMS), with the goal of becoming a more environmentally-responsible facility. One focus of the EMS, the "Green Initiative," helped reduce the Center's carbon footprint through energy-efficent usage of electricity and water.

Received Recognition for Achievements

Many staff received awards this year in recognition of their accomplishments. The awards included two Department of Commerce Silver Medals and a NOAA Administrator's Award. In addition, other Center staff who serve on and support the regional ocean governance committees and panels and collaboration teams have received thanks and acknowledgments from their external partners and NOAA leadership for their dedication and teamwork on these important activities.

Deputy Director John Stein meets with NOAA Administrator Jane Lubchenco. (left)

Scientists deploy CTD rosette. (middle)

Scientist collecting data from seining activity. (right)

Sockeye salmon swimming. (below)